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Citation for published version:
Wauthier, L, Society for the Prevention of Cruelty to Animals (Scottish SPCA), S & Williams, J 2018, 'Using the mini C-BARQ to investigate the effects of puppy farming on dog behaviour', *Applied Animal Behaviour Science*, vol. 206, pp. 75-86. https://doi.org/10.1016/j.applanim.2018.05.024

Digital Object Identifier (DOI):
10.1016/j.applanim.2018.05.024

Using the Mini C-BARQ to Investigate the Effects of Puppy Farming on Dog Behaviour

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Abstract

High demand for dogs in countries like the UK can lead to illegal intensive breeding and illegal importation of puppies for the pet trade. The current study investigates the effects of intensive breeding or 'puppy farming' on canine behaviour, explores new ways of predicting negative outcomes and categorising dog behaviour, and probes whether various types of training or routines can mitigate these behavioural outcomes. Participants completed an online self-report questionnaire, combining a shortened version of the Canine Behavioural Assessment and Research Questionnaire (mini C-BARQ) (Duffy et al., 2014), with new scales created in collaboration with the Scottish Society for the Prevention of Cruelty to Animals (Scottish SPCA). 2,026 participants completed the questionnaire; most owners had dogs from non-puppy farm backgrounds (n=1702), the rest had dogs from puppy farms (n=123), or were unsure of the source of the dog (n=201). We validated the mini C-BARQ as a tool for measuring dog behaviour, and explored its latent dimensions using factor analysis, extracting five first-order factors and one overarching second-order factor. We also confirm the validity of three of the four new scales developed with Scottish SPCA used to measure the impact of puppy farming practices. Linear and logistic regressions demonstrated that dogs from puppy farms have less desirable behaviours than dogs from other sources on 11 of the 14 behavioural subscales of the C-BARQ (for significant subscales, coefficients were between 0.1 and 0.2, and odds Ratios between 1.6 and 2.5). Generalized Linear Models (GLM) revealed the predictive power of two newly developed scales measuring early life experience in explaining variations in dog behaviour. In a GLM accounting for the dog's early life experience (and controlling for variables like breed and age), dog-walking significantly reduced the incidence of undesirable behaviours ($p<0.001$), while different types of training had a significant interaction with poor early life experience in moderating canine behaviour ($p<0.002$). Finally, dogs from puppy farms had significantly worse medical scores than dogs from other breeding sources ($U = 144{,}719$, $z = 7.228$, $p < 0.001$). These results suggest that puppy farming has negative impacts on dog behaviours and health, while more research is necessary to fully explore how to mitigate the effects of poor early life experience.

Key Words: Canine; Dog Behaviour; mini C-BARQ; intensive breeding; Puppy farming; behavioural development.

1. Introduction

Dogs are the most common type of pet (PFMA, 2017) and dog ownership increases with number of household members and if children are present (Downes et al., 2009), suggesting that dogs often play an important role in a family context. Dogs have been found to have a beneficial impact on children's emotional development (Vidovic et al., 2015), provide emotional support (Hawkins et al., 2017), and increase physical health in old age (Curl et al., 2016). However, problematic or extreme canine behaviours may hinder the positive role a dog can have: perceived problems like aggression and house soiling can precipitate increased family tensions (Power, 2008), while destructive tendencies and aggression are the most common reason for dogs to be relinquished to shelters (Diesel et al., 2010). Understanding how to reduce problematic behaviours is therefore important both in a family context and for dog welfare, but research on dog breeding, the environment it creates for early development, and the long-term behavioural implications is only starting to receive attention.

Intensive dog breeding (IDB) can take on a range of forms and has been given various names, such as 'puppy mills', 'puppy farms', or Commercial Breeding Establishments (CBEs). IDB tends to occur where an increased demand for dogs makes breeding a lucrative business, often to the detriment of dog welfare, where animals are kept in cramped, overpopulated conditions, and are selected as breeding stock irrespective of behaviour or health. Studies in the United States have shown CBEs have quite serious negative effects on adult dog behaviour, noticeably for fear and aggression (McMillan et al., 2013). However, IDB operations are poorly defined on an international scale as terminology is inconsistent: these sometimes refer simply to larger breeding operations, and sometimes to breeding operations specifically harmful to welfare. As a result, it can be difficult to build a global understanding of the effects of these practices, which will vary in their legality, the regulations applied, and consequently the welfare of animals. In line with current UK terminology (Scottish SPCA, 2018), and in order to underline the detrimental welfare effects and often illegal nature of these practices (rather than their scale), we will refer to IDB operations detrimental to welfare as *puppy farming* (see Everett, 2014 for a discussion of ethical terminology regarding puppy farming).

Over the last 30 years, puppy farming has created both legal and public concern in the UK, especially as accumulating evidence suggests puppy farming has significant costs, both in terms of animal welfare and for the families whose pets display health and behavioural issues. This problem has started being addressed with legislation regulating welfare and breeding practices[1], and with the trial of an assured breeder scheme in Scotland (Scottish SPCA, 2018). Although stricter regulation has probably reduced the number of legal IDB operations detrimental to dog welfare, it means that intensive breeders may choose to operate outside legislation (possibly operating with even worse welfare conditions) or that dogs will be imported from other countries with less stringent regulation (Dogs Trust, 2017). However, the mechanisms through which these intensive breeding practices influence dog behaviour are only starting to be investigated (McMillan, 2017), and there is little evidence concerning which aspects of puppy farming are most deleterious to canine behaviour and health, or how to mitigate the negative outcomes associated with puppy farming.

1.1 Effects of puppy farms on canine behavioural development and welfare

In a review of evidence, McMillan (2017) argues that behavioural differences between intensively bred dogs and those from other sources can be traced back to a combination of genetic, prenatal, and developmental factors. These are poorly managed in puppy farms, raising a series of concerns for the behaviour of those dogs as adults, and for their welfare (HSVMA, 2013).

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[1] In Scotland: The Breeding of Dogs Act 1991, Breeding and Sale of Dogs (Welfare) Act 1999, Animal Health and Welfare (Scotland) Act 2006, The Licensing of Animal Dealers (Young Cats and Young Dogs) (Scotland) Regulations 2009, Microchipping of Dogs (Scotland) Regulations 2016

Bitches are often bred continuously until they are no longer able to deliver puppies and are then discarded. Intensive breeding affects the bitch's health, immune function and ability to care for her pups. McMillan et al. (2011) demonstrated that breeding dogs in CBEs developed fears and phobias and learning deficits. These issues may transfer directly to the puppies, as studies have demonstrated that higher quality maternal care in dogs will tend to increase puppy social and physical engagement (Foyer et al., 2015), may aid positive interest in humans (Guardini et al., 2017), and that puppies may also learn to display certain behaviours from their mothers (Lord, 2010).

On the genetic side, careful breeding remains an effective way of influencing dog behaviour and health. A wide variety of dog behaviours have been studied for their heritability, such as aggression (Perez-Guisado et al., 2006), anxiety (Goddhard and Beilharz, 1983), or human-directed social behaviour (Persson et al., 2015), a process which has been made more precise since the mapping of the dog genome in 2005. Mandatory behavioural screening of pedigree parents has managed to successfully reduce aggressive temperaments in breeds such as Dobberman and Rottweiler (van der Borg et al., 2017). Likewise, screening the parents and avoiding reproduction of ailing individuals can significantly weed out congenital illnesses or deformities. Such behavioural and physiological screenings are not likely to be performed in puppy farms, suggesting that genetically-caused behavioural and medical issues are not likely to be addressed.

Developmentally, puppy farming affects the welfare of puppies because it does not provide an appropriate environment for canine behavioural development. Dogs have a set of six relatively well-defined stages of behavioural development (Serpell et al. 2016). During these sensitive periods, the puppy farming environment may adversely affect puppies' behavioural development, especially during first four stages: prenatal, neonatal, transitioning, and socialisation.

During the prenatal period, developing pups are influenced by maternal levels of cortisol and androgen, which has been linked to increased stress sensitivity among rats and foxes (Champagne, 2008; Braastad et al., 1998). Maternal stress in rodents also affects the amount of care pups receive in the neonatal period (first two weeks), which has long-term consequences for their regulation of their Hypothalamic-Pituitary-Adrenal (HPA) axis (Champagne et al., 2003). The high levels of stress bitches are likely subjected to in puppy farms will therefore have direct and systematic deleterious effects on the puppies, both prenatally and during the neonatal period.

The transition period, in the third week, marks the maturation of puppies' sensory systems (opening of their eyes and then their ear canals) until the onset of motor development in the fourth week, signalling the onset of the socialisation period. It is during this exploratory socialisation period (4-12 weeks), that puppies are most directly influenced by their environment. During this period, it is crucial that pups are exposed both to the human and environmental factors that they are likely to interact with, as they may otherwise never fully habituate (Scott and Fuller, 1965). Variations on the socialisation timing can partially explain behavioural differences amongst breeds, subtle differences that puppy farmers are unlikely to take into account. For example, German shepherd puppies show stronger novelty avoidance at 5 weeks than Labradors, who are more flexible and retain the opportunity to socialise in their new home for longer (Lord et al, 2016). Puppy farming affects the patterns of socialisation in three ways: firstly, the kennel environment contains a narrower range of stimuli and reduces human contact. Since dogs also form 'localisation' attachment (Scott and Fuller, 1965), this suggests that dogs from kennels will show increased fear responses as adults *both* to humans and their environment (Appleby et al., 2002). Secondly, dogs are unlikely to be socialised properly, or according to the needs of their breed. Finally, puppies are often sold at or before eight weeks of age, during one of the most sensitive developmental phases; if puppies are shipped from overseas, long transportation will translate to high stress levels and have long term effects on behaviour.

Welfare issues continue after intensively bred dogs are bought as pets, because both health and behavioural issues increase the likelihood that a dog will be relinquished to a shelter (Duffy et al., 2014). Based on anecdotal evidence, the UK Kennel Club states that "puppies bred by puppy farmers are more likely to suffer from common, preventable, infectious diseases, painful or chronic inherited conditions, behavioural issues and shorter life spans". Our research will scientifically investigate these claims.

1.3 Research aims

The first aim of this research was to investigate different ways of measuring the effects of puppy farming. This was done by validating four short new scales developed with the Scottish SPCA, and validating the use of the mini C-BARQ (Duffy et al., 2014) with the current sample. In order to maintain statistical power in further analysis, Exploratory Factor Analysis (EFA) was used to determine whether the mini C-BARQ could be validly condensed along latent behavioural dimensions.

The second aim was to investigate the effects of puppy farming on medical health and behaviour. The investigation on behaviour attempted to replicate the results of McMillan et al. (2013), who used the C-BARQ (Hsu and Serpell, 2003) to demonstrate the negative effects of intensive breeding on various behaviours including aggression, fear, separation anxiety, and a variety of other behavioural problems. The current research aimed to reproduce their results within the UK context, although we note a few differences. First, rather than using the full-length C-BARQ, the current study used the mini C-BARQ (Duffy et al., 2014), which allowed for additional questions to be included without making survey length prohibitive, probing aspects such as the living conditions of the dog at purchase, and their health condition. Second, the questionnaire was advertised through a different set of routes and may have reached a different participant sample: while McMillan et al. advertised through veterinary practices, the current research advertised primarily through animal rehoming centres, welfare charities, and social media. Finally, this study used a different set of comparison groups: while McMillan compared breeder-obtained dogs (excluding home-bred, rescued, or dogs obtained from a friend/relative) to pet-store bought dogs (proxy for CBEs), the current study compared dogs categorised as coming from puppy farms to those from any other sources. Despite these differences, we hypothesised similar effects would be found in the current study: dogs from puppy farms will be found to score significantly worse on most, if not all, of the C-BARQ measures.

The third aim was to explore how basic measures taken by the owner could mitigate the effects of poor early life experience. Research has demonstrated that different types of training, such as puppy classes, can significantly improve the behaviour of dogs (Kutsumi et al., 2013). Little research has been carried out for other simple measures, such as whether the frequency of dog walking can improve behaviour. We hypothesise that both dog walking and dog training will decrease the incidence of negative behaviours as measured by the mini C-BARQ.

2. Methods

2.1 Design

This research used a cross-sectional online questionnaire-based survey design. A self-report questionnaire was designed consisting of standardized and newly developed measures and distributed using Bristol Online Survey. The online questionnaire was open from the 7th of June to the 27th of July 2017.

2.2 Participants

Participants were recruited through a combination of non-probability sampling methods (i.e. where the sample may not be representative of the general population because of biases potentially introduced when reaching participants). Most participants were recruited online through convenience sampling (drawing the participant sample from the set of people easiest to reach) although every care was taken to publicise through a wide variety of pertinent organisations. The questionnaire was publicised through press releases by the Scottish SPCA, the University of Edinburgh, and via social media, with a short synopsis describing the purpose of the research and a direct link to the questionnaire. The Scottish SPCA reached out to their contacts and asked them to forward or publicise the questionnaire further. The organizations contacted included: Blue Cross, Dogs Trust, RSPCA, ISPCA, Kennel Club, Association of pet behaviour councillors, Scottish Government Researchers, and Association of Pet Dog Trainers. The questionnaire was also forwarded to the Scottish SPCA's Head Vet, who then circulated the link with their contacts. Finally, a small number of participants, who were known by the Scottish SPCA to have obtained their dog through the puppy trade, were directly contacted and asked to complete the questionnaire.

Of the 7,268 people who accessed the questionnaire, 2,787 started completing the questionnaire, corresponding to a response rate of approximately 38%- fairly typical for online survey formats (see e.g. Nulty, 2008). Of those that proceeded, 2,026 (72%) completed the full questionnaire, of which 93% were female (n= 1891). This female gender bias, though potentially creating a skew in responses, is fairly common in questionnaires (Smith, 2008). Furthermore, research by Dodman et al. (2018), which investigated the effects of owner personality on dog behaviour using the mini C-BARQ, had a very similar gender bias with 91% of respondents being female. Participants were almost all from the UK (n=1889, with 1549 from Scotland, 286 from England, 25 from Northern Ireland, and 29 from Wales). Other participants were from the Republic of Ireland (n=91), and 46 participants were from other countries (including the USA and Canada). Dogs were 51% male, and the majority of dogs had been neutered (65% of males and 68% of females). Median dog age fell in the 2-5 years old category.

2.3 Materials and measures

The questionnaire comprised five sections: (1) participant demographic information, (2) basic information about the participant's dog, (3) information concerning the purchase of the dog, (4) behavioural assessment of the dog, and (5) canine medical health questions (see Supplementary materials for full questionnaire). All sections except the fourth were designed in coordination with the Scottish SPCA to probe variables known to impact dog care, as well as possible indicators that dogs had been bred on puppy farms, and common medical issues. The fourth section, which measured the dog's behaviour, utilized the shortened version of the C-BARQ.

Basic information about the participant's dog: This section of eleven questions was designed to obtain basic information about the dog and the way it was handled, providing most of the control variables for the current analysis. Five questions made up the 'Owner Care' scale (α=0.353), which asked participants what training they had completed with their dog, how often they took their dog on walks, and whether their dog regularly met dogs from outside the household.

Information concerning the purchase of the dog: This section probed different aspects of the context from which participants obtained their dog. Items were suggested by the Scottish SPCA as being predictive of whether the dog came from a puppy farm, and included two newly developed short scales. The "Puppy Experience Scale" (α=0.778) had ten questions, and investigated how the puppy had been living at the time of purchase. It included questions such as whether the current owner had met the dog's mother and father, and whether other litters of puppies were for sale. The 'Seller Experience Scale' (α=0.750) had seven questions, and asked participants about their interaction with the seller at the time of purchase, including whether the seller was licensed, and whether they would recommend or return to the seller.

Behavioural assessment using the mini C-BARQ:

The Canine Behavioural Assessment and Research Questionnaire (C-BARQ) © (Hsu and Serpell, 2003) is a self-report questionnaire which probes the severity of 14 behavioural subscales and several miscellaneous items. It has well-established validity and replicability, and has been used to investigate a variety of dog behaviours, including temperament (Barnard et al., 2012), trainability (Duffy and Serpell, 2012), and aggressive behaviour (Berg et al., 2010). Existing studies using the C-BARQ have also helped establish factors commonly influencing dog behaviour, including age, sex and neuter status (Hsu and Sun, 2010), dog size/weight (McGreevy et al. 2013) and breed (Tonoike et al., 2015).

In its full form, the C-BARQ is a 100-item questionnaire which investigates dog behaviour along 14 behavioural subscale dimensions, and with a list of miscellaneous items. The questionnaire is completed by the dog's principle owner or handler, who must select an answer for each item along a five-point scale which represents either severity of behaviour (i.e., 0 = no signs of the behaviour, 1 to 3 = mild to moderate signs of the behaviour, and 4 = severe signs of the behaviour) or its frequency (i.e., 0 = never, 1 = seldom, 2 = sometimes, 3 = usually, and 4 =always), depending on the question.

Questions are accompanied by a general description of the behaviour type (e.g. aggression or fear), and examples of typical behaviour were given at extreme points for each scale. In order to minimize participant drop-out rates we used the mini C-BARQ, which has 42 items and takes under ten minutes to complete. It was found to be highly consistent with the C-BARQ, and was developed using a large sample of dogs using step-wise removal of items and using Cronbach's alpha to determine impact on internal consistency (Duffy et al., 2014). This shortened version had 14 subscales and nine miscellaneous items.

Canine Health-related Questions: Physical health outcomes were measured using a set of eight questions ('Medical Symptoms', α=0.713), investigating the general physical health of the dog, which was adapted from a recent Scottish Government funded survey (Wyatt et al., 2017). Questions included whether the dog had ever required veterinary treatment, suffered from viruses or respiratory illness, or been underweight. Finally, participants were given a free text box if they wished to leave any comments.

2.4 Procedure

Participants completed either an online or hard-copy version of the questionnaire. Both versions of the questionnaire had a cover page, which detailed the purpose of the study, the information that participants would be asked to complete, and an estimated time it would take to complete the questionnaire (ten minutes). Participants were also informed that their responses were confidential and anonymous, that they could withdraw at any time they wished, and were required to tick a box confirming that they consented to take part in the survey. In the online version of the questionnaire, almost all questions were required, the only exceptions were questions which may not have applied to all participants. Ethical approval was obtained from the University of Edinburgh's Clinical and Health Psychology Research Ethics Committee.

Assigning dogs to the 'puppy farming' category was done based on participant's response to the question: "Do you believe your dog was bred as part of intensive breeding/puppy farming?", to which participants could respond “Yes”, “Unsure”, or “No”. Responses marked “unsure” were excluded from analysis; of the remaining dogs, 7% (n=123) were reported by owners to come from puppy farms, and the remaining 93% (n=1,702) had dogs from other sources. Although the questionnaire was distributed to known owners of puppy-farmed dogs (from the SPCA’s list of contacts), it was impossible to confirm the owner’s report because the questionnaire was anonymous.

2.5 Data analysis

2.5.1 Preliminary data handling

Dog breed was a free response section in the questionnaire. For analysis, this was coded according to the seven breed groups as listed by the UK Kennel Club, with an additional category for Cross breeds, and a category titled ‘Wolfdog’ (n=16) describing a set of breeds not officially recognised by the Kennel Club (e.g. Czechoslovakian Vlcak).

C-BARQ subscales were calculated in accordance with Duffy et al. (2014), and the instructions of the corresponding author (Serpell, email communication, August 1st 2017). The histograms of the subscales were then explored to identify scales that were seriously skewed. Nine subscales were identified and dichotomized following the procedure in McMillan et al. (2013) so that logistic binary regression could be performed. This was done by recoding the lowest (most common) score as 0, while any score above this was recoded as 1. The five remaining subscales did not violate the assumptions of normality too significantly and so were not transformed.

2.5.2 Statistical Procedure

All data was handled and analysed using IBM SPSS version 22. There were three stages to data analysis: reliability analysis and EFA of the mini C-BARQ and newly created scales, replication of the results from McMillan (2013) investigating difference of behaviour between dogs from puppy farms and other backgrounds, and GLMs exploring the predictive power of the newly created scales and moderating factors in accounting for dog behaviour beyond the effect of puppy farming.

Four new scales were analysed: ‘Medical Symptoms’, ‘Puppy Experience’, ‘Seller Experience’, and ‘Owner Care’. Those scales that had Cronbach’s alpha above 0.7 were considered to have ‘good’ reliability, and be suitable for further analysis (Field, 2103). Certain scales underwent Principle Components Analysis (PCA), which was performed using Direct Oblimin rotation, and extracting factors with eigenvalues above 1. Reliability analysis was once again carried out on the extracted subscales; because these had fewer items, α or ρ above 0.6 were considered acceptable for the purpose of calculating an average score for that subscale.

Once the validity of the mini C-BARQ’s 14 subscales was investigated with the current sample, its psychometric properties were investigated using an approximation of hierarchical EFA. This was achieved through several rounds of Factor Analysis, which is appropriate for the extraction of latent constructs (Floyd and Widaman, 1995) using Oblimin rotation because the extraction of higher level factors assumes lower level factors have common variance and are not orthogonal. Two rounds of EFA were performed: the first level was performed on the 14 C-BARQ subscales, and the second on extracted factor scores which were calculated using regressions scores. The number of factors to extract was determined using Horn’s Parallel analysis (Horn, 1965) which determines the number of factors to retain based on eigenvalues which are greater than those from a randomly generated correlation matrix.

Hierarchical binary logistic regression (for recoded variables) or hierarchical linear regression (for variables which did not violate the assumptions of normality of residuals) were used to investigate the behavioural effects of puppy farming (n=123) when compared to other sources of dog breeding (n=1702) (201 cases were excluded where owners were not sure of the origin of their dog). These regressions controlled for five factors: age, sex, neuter status, breed, and whether they lived with other dogs. Although there is some debate as to whether ordinal data can be analysed using linear regression, Norman (2010) confirms that Likert-type data measuring continuous constructs can be analysed parametrically, as long as other assumptions of regression (e.g. normality of the means) are not violated. These analyses were performed hierarchically, controlling for other variables in the first block, and with puppy farming in the second block. P-values below 0.05 were used to identify significant predictors in the model, and non-significant predictors were removed in order to avoid over-fitting. In the final models, the Benjamini-Hochberg correction (Benjamini and Hochberg, 1995) for false discovery rate (with Q=0.05) was applied for the effect of puppy farming (control variables were not included in this correction). The effect of puppy farming on medical health was investigated by comparing medical scores across dogs from puppy farms or from other sources, using a non-parametric Mann-Whitney U test.

The final step of the analysis was an exploration of whether the newly created 'Puppy experience' (PE) and 'Seller Experience' (SE) scales could predict C-BARQ score beyond 'puppy farm' classification. These were analysed using Generalised Linear Models (GLMs), which allows fitting of non-normal regressions. Thus, the highly skewed subscales that had previously been binary transformed were analysed using Gamma regressions with Log link, which, based on the value of the Akaike Information Criterion, was found to be the most appropriate non-normal regression model. Those subscales that were not transformed continued being analysed using hierarchical linear regressions.

This allowed an investigation of whether walking and training exposure moderated these behavioural outcomes. The effect of walking and training on dog behaviour was investigated by inputting these terms as main effects and through the inclusion of interaction terms in hierarchical linear regressions using the extracted factors from the EFA. Thus, these analyses were performed on six extracted factors: five factors extracted as first order factors, and one general factor was extracted as a second order factor. We chose to investigate the effect on behaviour by using these six factor scores, rather than on a subscale basis, because it reduced the likelihood of Type I errors (by running one test rather than 14), or of losing too much statistical power by having to correct for multiple tests. The factor scores were calculated using a simple average of the items loading most strongly (and above 0.3) onto each factor. This method was chosen because using weighted averages (i.e. regression scores) may cause issues due to factor indeterminacy, may be less stable across samples, and will produce results that are more difficult to interpret (see DiStefano et al., 2009). As this research was exploratory in nature, using averages provides a more stable solution for comparison with future research. In order to reduce multicollinearity and stabilise model fit, independent variables were centred (by subtracting the mean), and interaction terms were calculated by multiplying the centred independent variables (Afshartous and Preston, 2011). Finally, the Benjamini-Hochberg correction for false discovery rate (with Q=0.05) was applied before interpreting significance.

3. Results

3.1 Scale reliability and analysis

All scales except the 'Owner Care' had α above 0.7, and so were retained (see Table 1). Sub-items in the 'Owner care' scale were investigated separately. It was found that the question "Does your dog obey basic commands (sit, stay, down, etc.)?" was highly skewed, with 96% of respondents reporting 'yes'. As a result, this item was removed, and two possible subscales each with two items remained. Because these two subscales only had two items each, the Spearman-Brown split-half reliability estimate was used instead of Cronbach's alpha (Eisinga et al., 2013). The 'training' subscale (investigating attendance to puppy classes and whether the owner did clicker training) had low reliability (ρ= 0.336), and so was not considered a valid subscale. However, the 'walking' subscale, which investigated how often the owner took their dog on walks and how often the dog met unfamiliar dogs, had adequate reliability (ρ= 0.618).

The 'Medical Symptoms' scale was further analysed using PCA to investigate whether there were consistent patterns in the types of illnesses being reported. PCA extracted two factors, each of four items. Factor 1 was named 'Chronic Illnesses' (items: 'Has your dog required veterinary treatment for illnesses', 'Suffered from skin conditions', 'Suffered from common illnesses', and 'Suffered from inherited disorders') and had α=0.63. Factor 2 was named 'Environmental/Infectious Illness' (items: 'Suffered from viruses such as parvovirus, canine brucellosis, canine distemper', 'Suffered from respiratory illnesses such as kennel cough, pneumonia', 'Suffered from parasites', and 'Been underweight') and had α=0.60. Although both these scales have borderline reliability (under 0.7), this may be due to the small number of items in each scale.

[Insert Table 1 here]

The mini C-BARQ subscales were investigated for reliability and validity, and PCA was performed to determine whether the same factors reported in Duffy et al. (2014) would be extracted. The overall α for the mini C-BARQ was 0.851, suggesting it might be appropriate to analyse as a single scale. A total of 11 factors were extracted. The extracted subscales were broadly consistent with those in Duffy et al., (2014), although certain scales collapsed into each other (non-social fear with stranger directed fear, owner-directed aggression with dog rivalry, and dog-direct fear with dog-directed aggression). Subscales were calculated according to the categories in Duffy et al. (2014), and reliability was calculated using α. A comparison with the current scores show good replicability of the previous reliability results (see Table 2).

[Insert Table 2 here]

Several rounds of EFA was performed on the 14 extracted subscales to determine whether there were any latent constructs and factors of higher generalisability. EFA on the 14 subscales extracted five factors (see Table 3), quite neatly: these have relatively little cross-loading, and each subscale has a factor loading of at least 0.3 on at least one factor. The α for the new factors were all above 0.6. Based on the loading subscales, the five extracted factors were named ‘Fear’, ‘Attachment issues’, ‘Familiar aggression’, ‘Impulsiveness’, and ‘Unfamiliar aggression’. Another round of EFA was performed on the five extracted first order factor regression scores. This extracted one general factor (see Table 4). Since the factor loadings onto this general factor do not seem highly biased towards any one of the first order factors, this suggests the second order factor may correspond to overall behavioural reactivity, and the dog’s ability to regulate (and inhibit) undesirable behaviours. This suggests a latent hierarchical structure to the C-BARQ with five first-order factors and a general second order factor (see Figure 1).

[Insert Tables 3 and 4, and Figure 1 here]

3.2 Breed groups and puppy farming

In order to explore which breeds are most likely to be targeted by puppy farming, and to understand how this may affect analysis of behaviour (breed and size both affect dog behaviour), an exploration was performed to determine how the different breed groups were separated between the puppy farming and non-puppy farming samples. The 'Toy' breed group was found to have the highest percentage of dogs from puppy farms (16.5%), as all other groups had under 9% of dogs from puppy farms. The 'Gundog' breed group had the lowest percentage of dogs from puppy farms (2.6%). Within the group of dogs which came from puppy farms, most dogs were cross-breeds (most likely desirable crosses such as labradoodles of Cockapoos), at about 30%, with the Toy and Terrier groups also making up a large percentage of the dogs form puppy farms (at 18.7% an 15.4% respectively).

[Insert table 5 here]

3.3 The effects of puppy farming on dog behaviour and medical health

Dogs bred on puppy farms differed significantly from those acquired from other sources on 11 of 14 of the mini C-BARQ behavioural subscales. This effect was always negative, with puppy farming being linked to higher (less desirable) C-BARQ scores (Tables 3 and 4). Dog-rivalry, Energy and Chasing were the only scores in which puppy-farm raised dogs and those from other sources did not differ. For all other variables, dogs from puppy farms showed a 60-90% increase in likelihood of demonstrating undesirable behaviours (in logistic regressions) or a 10-20% increase in subscale score (in linear regressions).

[Insert Tables 6 and 7 here]

The effects of puppy farming on medical health was also explored. As medical scores were skewed towards low scores, non-parametric tests were used (distributions between groups were equivalent so means are reported). A Mann-Whitney U test showed a significant difference in 'Medical Symptoms' score (an average of all medical items, possible values from 1-5, with 1 indicating no symptoms) between dogs from puppy farms and dogs from other sources. Mean 'Medical Symptoms' score was statistically significantly higher in puppy-farm dogs (1.57) than in dogs from other sources (1.29) ($U = 144{,}719$, $z = 7.228$, $p < 0.001$). In order to determine whether there was a difference in the type of illnesses reported, separate Mann-Whitney U tests were then run for each of the medical subscales. There was a significant difference in 'Chronic Illness' scores ($U= 141{,}371$, $z=6.675$, $p <0.001$), with dogs from puppy farm having higher mean scores (1.89) than those from other sources (1.45). Puppy farm dogs also had significant higher 'Infectious Illness' scores (mean= 1.26) compared to dogs from other sources (mean=1.13, $U=127{,}464$, $z=5.124$, $p < 0.001$). Note that the difference in means for 'Chronic Illnesses' ($\Delta\bar{x}= 0.44$) is more than three times larger than for 'Infectious Illness' ($\Delta\bar{x}= 0.13$), suggesting the former may have a larger effect.

3.4 Analysis of new subscales and factors moderating differences in dog behaviour

To confirm the validity of the Puppy Experience (PE) and Seller Experience (SE) scales, these were tested for their ability to identify dogs coming from puppy farms. A Mann-Whitney U test showed a significant difference in the score of the PE scales with dogs from puppy farms having significantly higher scores than dogs from other sources ($U=182{,}903$, $z=14.03$, $p<0.001$). Similarly, for the scores on the SE scales dogs from puppy farms had significantly higher scores than dogs from other sources ($U=162{,}046$, $z=15.20$, $p<0.001$).

The ability of the PE and SE scales to more sensitively predict changes in behavioural score than the puppy-farm/other breeding dichotomy was tested by inputting the three variables as predictors into GLMs for each subscale (control variables from the first set of regressions were not included as these complicated the interpretation of changes in coefficient/significance). Of the 14 regressions, 11 explained variance in canine behavioural score better with the inclusion of the PE and SE scales, rather than just the puppy-farming variable. Of these, two subscales had all predictors significant, while six subscales were significant for both SE and PE, which caused the puppy-farming factor to lose significance. Two regressions which had not been significant for puppy-farming in the first set of regressions showed significance for the SE scale (Dog Rivalry and Energy), while the Trainability scale showed significance for PE. Of the three scales which were not influenced by the inclusion of PE or SE, two regressions were non-significant for any variables (Chasing and Excitability), while Attention-seeking was significant only for the puppy-farming. As a result, the SE and PE predicted variance in most behaviours beyond that explained by puppy-farming, and in some cases replaced puppy farming as more significant and sensitive predictors (see Supplementary data).

Finally, engagement in dog walking and different types of training were tested for their ability to moderate the effects of adverse early life experience. Because the SE and PE scales were found to generally be more powerful predictors, these scales were used to investigate the interaction effects. However, because of the high number of interaction terms that would otherwise be involved, the SE and PE scales were combined into a wider "Early experience scale" (EES), which had adequate reliability (α=0.82). The final model under investigation had seven terms: four main effects (clicker/reward training, puppy training classes, walking scores, and EES) and three interaction terms ('clicker/reward training' x EES, 'puppy classes 'x EES, and 'walking' x EES).

This model was applied to explain variance for each of the extracted factors first order factors, 'Fear', 'Attachment issues', 'Familiar aggression', 'Impulsiveness', and 'Unfamiliar aggression', and the overall 'General' factor. The 'General' factor was analysed using a hierarchical linear regression with three blocks (see Table 8). The first block contained the controls from previous tests, the second block contained the main effects, and the third block the interaction terms. Each block was found to significantly increase model fit, and the final model explained nearly 12% of the variance. Of the main effects in block 2, only EES and 'Walking scale' had a significant effect. However, in block 3 the interaction term for walking had no effect, while those for the two types of training did. This suggests that while more walking reliably reduces C-BARQ score, training has no reliable effect on C-BARQ score by itself. Because the interaction terms have negative coefficients (while the main effects have positive coefficients), this suggests that for an equivalent increase in EES, increases in training score (i.e. *less* training) *reduces* the effect (slope) of EES (see Figure 1). This seems counter-intuitive: we would expect *more* training to reduce the effects of negative early life experience. However, looking closely at Figure 1, it is apparent that the regression lines cross-over. Thus, the correct interpretation may not be regarding the overall ability of training to moderate the effects of poor early life experience, but rather that training only has a beneficial effect for those dogs that did *not* have poor early life experience (from the graph we can see that those who receive training actually have lower C-BARQ scores for low values of the 'Early Experience' scale). The reason training may appear to give worse behavioural outcomes for higher scores on the EES may simply be an artefact: the distributions of both C-BARQ and EES are skewed to the lower values; since the lower ends of the scale have more data, this is what the regression attempts to fit. Training may not uniformly alter the relationship between 'Early Experience' and C-BARQ score, having a (slight) beneficial effect *only* on the lower ends of the scales. However, even if training *does* have a uniform effect, the skew masks the effect of data at higher ends, so that it becomes impossible to predict whether the interaction is also valid for higher values.

[Insert Table 8 and Figure 2 here]

Because the mini C-BARQ is designed to measure a variety of behaviours an analysis of overall score may mask some interesting effects. As a result, we performed the above analysis for each of the extracted first order factors. These analyses were performed by choosing the best model fit based on the dependant variable's distribution ('Fear' and 'Unfamiliar Aggression' were lognormal distributed, and fit with a Gaussian with log-link model, 'Attachment' and 'Impulsiveness' were normal and fit with a normal GLM, and 'Familiar Aggression' was very skewed and so transformed into a binary variable and analysed with a Binary logistic model). As before, control variables were included, followed by main effects and interaction terms. Table 9 presents a summary of these effects. Of particular interest is the fact that although there are broad similarities regarding which variables have an effect, there are also distinct patterns for each of the first order factors. For example, Early Experience had a significant effect across the board, while Clicker/reward training did not. However, puppy classes was a highly significant moderator only for attachment issues and was borderline for impulsiveness. Interaction terms also had varying patterns of significance for each first level factor. For example, the Clicker/reward interaction with Early Experience was highly significant for impulsiveness, and borderline for Attachment, while the Puppy classes interaction was only significant for Fear and Unfamiliar Aggression.

[Insert Table 9 here]

1. Discussion

4.1 Scales measuring the effects of puppy farming

The first aim of this research was to investigate the validity of both established and new scales for measuring the effects of puppy farming on dog behaviour and health.

4.1.1 New scales

The 'Puppy Experience' and 'Seller Experience' scales both had high reliability, which suggests that several factors indicative of intensive breeding tend to be present at once. These scales may be used as indicators of intensive breeding in cases where puppy farming is uncertain. Furthermore, these scales predicted overall C-BARQ score better than a simple classification of dogs into a binary puppy farm/other category, suggesting that intensive breeding might be understood as an accumulation of factors, which impact behaviour in a graded way. These two scales can also be merged into an overall score, given their high reliability when combined.

The 'Owner Care' scale was the only measure that had very poor reliability, and so could not be combined into an overall score. This suggests that engaging in one type of care does not predict whether the owner will participate in others. It may be fruitful to investigate whether other variables can predict levels of owner engagement, and to devise a broader dog care engagement scale (e.g. how much time does the owner spend with their dog every day, or how often they groom or play with their dog).

4.1.2 Replicability and EFA of the mini C-BARQ

This is the first replication study of the shortened version of the mini C-BARQ. Results suggest broad agreement with the results of Duffy et al. (2014) for subscale dimension, and high levels of agreement concerning their reliability. Furthermore, the mini C-BARQ yielded similar results to those of McMillan et al. (2013), who used the full questionnaire, lending further support to the validity of the scale. The way the subscales collapsed into each other in the current dimensional analysis (non-social fear with stranger directed fear, owner-directed aggression with dog rivalry, and dog-direct fear with dog-directed aggression) suggests overarching concepts: fear, for example, may generalize to strangers and objects, dog aggression may be mediated by fear, and aggression within the household may generalize to owners and dogs.

The way in which behaviours measured by the mini C-BARQ correlate and may represent underlying latent constructs was further investigated using EFA. Although the C-BARQ, as a measure of distinct behavioural issues, was not originally designed to be averaged into overarching factors, the EFA may lend further validity to the measure. First order factors (‘Fear’, ‘Attachment issues’, ‘Familiar aggression’, ‘Impulsiveness’, and ‘Unfamiliar aggression) separated neatly, suggesting that the C-BARQ investigates a set of distinct behaviours, and it also implies the C-BARQ is not reducible to a single or smaller set of items. These first order factors loaded approximately evenly onto a single higher order ‘General’ factor. The extraction of this general factor, and the high α of the overall scale, suggests that behavioural problems in dogs tend to correlate and that the C-BARQ has been well designed to measure an overarching, multi-dimensional phenomenon. Although these correlations do not provide evidence for a causal mechanism linking behaviours, it may be interesting to consider what biological mechanism underlie the pattern of correlations extracted by the current analysis. Firstly, subscale loadings onto the first order factors make intuitive/biological sense, lending tentative validity to the extracted factor structure, and suggesting that finding a biological explanation for these correlations may be valid. Secondly, many of the behaviours in the C-BARQ concern a dog’s reactivity and behavioural regulation in various contexts. If this is what is captured by the extracted General factor, then the biological mechanism which underlies this correlation may be of interest.

Current research suggests that HPA axis activity may be linked amygdala reactivity through the elevation of cortisol (Tottenham and Sheridan, 2010), and that early life stress may mediate increases in HPA axis activity through methylation (Bogdan et al., 2016). If behavioural and emotional reactivity are linked to HPA axis activity, this may be what underpins the correlation in dog's reactive behaviours measured by the C-BARQ and may account for the extraction of the 'General' factor.

Previous research by Svartberg and Forkman (2002) exploring dog personality using tests and behavioural observation lends tentative support for the extracted factor structure. Svartberg and Forkman also extracted five first order factors (Playfulness, Curiosity/ Fearlessness, Chase-proneness, Sociability, Aggressiveness) and one second order factor (which they interpreted as a shyness-boldness continuum). Although their extracted factors do next precisely match those extracted in the current analysis, this is partially because the types of behaviour measured, purpose, and methods of their study were so different. Despite this, there are some interesting similarities: Curiosity/ Fearlessness is essentially the inverse of 'Fear', Aggression might be equivalent to 'Unfamiliar Aggression' and 'Familiar Aggression' (the latter was not studied), and Chase-proneness may loosely match 'Impulsiveness'. The link between our extracted factors and their Sociability factor is slightly less clear, although it may partially overlap with the 'Attachment difficulties' as it is a measure of positive approach to people. Their extracted factor of Playfulness does not match any of our extracted factors clearly, but this is most likely because the C-BARQ is concerned with negative problematic behaviour. Svartberg and Forkman's interpretation of their general factor as representing the 'shyness-boldness' continuum also has interesting parallels to the 'General' factor in the current analysis: shyness and boldness are linked to anxiety, which is linked to HPA axis reactivity (Landgraf et al., 1999), suggesting the same biological mechanism might drive the behavioural effects in both studies.

The application of psychometric techniques to the C-BARQ has not been, to our knowledge, performed before. It may be an interesting tool to further investigate, both because it allows the C-BARQ to be summarised into a smaller set of behaviours, and because if the extracted factors are found to be valid, this may provide insights into dog behaviour. This analysis also joins a growing body of literature concerning dog personality (see Wiener and Haskell, 2016).

4.3 Effects of puppy farming on dogs

The second aim of this research was to investigate the behavioural and medical impact of puppy farming on dogs. The results showed that dogs raised on puppy farms have higher rates of undesirable behaviours than dogs from other breeding sources, broadly confirming previous findings by McMillan et al. (2013). However, there were some differences: the current results showed no significant effect for the ‘Chasing’, ‘Energy’, and ‘Dog rivalry’ subscales, while McMillan et al. (2013) showed no effect for ‘Chasing’ and ‘Stranger-directed fear’. This is interesting, given that the strongest result (as measured by the Odds Ratio) in the current study was for Stranger-Directed fear. In fact, while the current results showed strongest effects for fear-related behaviours with dogs more than twice as likely to show fear both to strangers and to other stimuli if they came from a puppy farm, McMillan et al. (2013) reported the strongest effects for aggressive behaviours. These differences may be due to their inclusion of additional control variables (dog weight and working versus recreational role), or perhaps differences in sampling, as they only studied dogs obtained either directly from breeders or pet stores, whereas the current study had a more varied mix of dog origins. However, it also raises the possibility that these different patterns of behaviour arise because of differences between UK and US intensive breeding regimens. For example, in the UK dogs originating from puppy farms are often imported due to stricter UK legislation: they may have longer and more stressful transport conditions, an event which likely has long lasting effects, as high levels of stress in early development have been shown to influence the development of the HPA axis (Caldji et al., 2001). Furthermore, there may be differences in the way the puppies tend to be handled, which may impact their socialisation and elicit different levels of stress. One of the most common consequences of inadequate socialisation in dogs is increased fearfulness in adulthood (Scott and Fuller, 1965).

Puppy farming was also found to increase the number of medical symptoms. The higher rates of illness support evidence which shows that dogs bred in commercial establishments have higher rates of genetic disorders (ASPCA), and higher rates of infectious disease such as parvovirus ("Kennel Club Puppy Farming"). There may be a larger difference between the means of puppy farm and non-puppy-farm dogs for chronic illness than for infectious illness, although these issues require further exploration.

4.4 Investigating moderating effects of training and dog walking

The third aim of this study was to investigate possible moderating factors in the behavioural outcomes of puppy farm dogs. This was investigated using the extracted five first order factors and the General factor (overall mini C-BARQ score). In the overall model, higher levels of dog walking improved behavioural outcomes, while the different types of training were significant as interaction effects. This might suggest that owners can take action to mitigate the effects of poor early life experience, but results must be interpreted carefully: the positive effect of increased walking were quite small, while the effects of training were difficult to interpret due to the nature of the interaction. The marginal effect of training is puzzling, as training has repeatedly been linked to better behavioural scores (Bennett and Rholf, 2006). This might come from the fact that training was probed using yes/no questions, whereas more graded measures of training involvement might have been more accurate.

These results were further explored with the first order factors in order to build a more fine-grained picture of the effects of moderators. The pattern of significant effects is interesting for two reasons: it provides tentative validation of the extracted factor structure due to the presence of both general effects (e.g. overall effect of Early Experience) and factor-specific effects (e.g. differential effect of 'puppy classes' and 'walking' for various behaviours), and the extracted patterns for each first order factor suggest different behavioural categories are influenced in different ways. For example, 'Attachment Difficulties' was most strongly affected by activities which suggested owner engagement (puppy classes, walking), suggesting that owner engagement may promote more positive dog attachment and alleviate attachment issues. Impulsiveness was the only behaviour influenced by the interaction between Clicker training and Early experience, suggesting that clicker training may be helpful in cases where a dog needs to manage impulsive tendencies, particularly where this has also been influence by the dog's early life experience. Finally, it is interesting to note that the Fear and Unfamiliar Aggression factors had essentially identical patterns of influence: they both had walking significant as a main effect and the Early Experience*Puppy classes significant as an interaction effect. This may again suggest that many aggressive behaviours towards unfamiliar people and dogs are actually rooted in fear, which would explain why both behaviours are influenced in the same way.

4.5 Synthesis of findings and implications

These results concur with findings of McMillan (2017) and suggest that puppy farming produces dogs that are less suited to the family environment due to long lasting behavioural and health issues. This affects dog welfare and human-animal interaction placing vulnerable family members, such as children, at risk. However, responsible dog ownership, including moderator variables such as dog walking and training, can influence the long-term welfare outcomes for dogs bred in puppy farms.

The intensive breeding environment affects two factors influencing canine behaviour: increased stress (both of the pups and mothers) and decreased socialisation (to humans, conspecifics and environment). These have wide-ranging effects on the development of the dog's nervous system, potentially leading to dysregulation of the HPA axis, which can affect reactivity, both as a 'positive' affect (e.g. excitement, attention-seeking) or a negative affect (e.g. fear or aggression), both measured by the C-BARQ. Increased reactivity and a dysregulation of the HPA axis has been linked to a variety of mental health disorders in humans (Shea et al., 2005), suggesting that the issues raised by these practices generalize to a broader literature investigating the interaction between genetics, poor early life experience, and adult behaviour in many animal species. Studying the effects of puppy farming therefore provides an opportunity both to increase animal welfare, and to explore fundamental issues concerning behavioural development and the interaction of risk factors.

4.6 Methodological limitations and further research

A variety of issues are associated with using convenience sampling and questionnaire designs. Although every care was taken to publicise the questionnaire through a variety of routes in order to achieve the largest pool of participants possible, it is likely that most participants had higher-than-average interest in animal welfare. The data relied on a voluntary, self-selected sample, and reflected self-reports provided by owners which may have introduced biases. Although Duffy et al. (2014) demonstrate that respondent knowledge of how the survey information might be used had no significant impact on owners' responses, it is still possible that owners' expectations influenced their answers. Future studies may wish to use more verifiable measures of outcomes. Furthermore, because the questionnaire was anonymous, there was no way of independently verifying owner's reports of the origin of their dog, which introduces potential reliability issues. For example, owners may not have consistent definitions of puppy farming, or may not be aware of the origin of their dog. However, these concerns are partially mitigated with the analysis of the 'puppy experience' and 'seller experience' scales, which probed factors known by the SPCA to be indicators of puppy farming. Dogs reported as coming from puppy farms had consistently much higher scores (more indicative of intensive breeding) on these scales than dogs from other sources, suggesting that owner's report of the origin of their dog has some validity. The analysis in this study is correlational, and cannot draw any causal conclusions. This may be especially important when studying moderating factors, such as training or dog walking.

Another limitation comes from the fact this study did not control for dog weight or size, which has been linked to an increase in problem behaviours such as separation anxiety and dog directed fear (McGreevy et al., 2013), as well as scent marking (McGuire & Bemis, 2017). The analysis of which breed groups tend to come from puppy farms does suggest these may favour smaller breeds, such as those coming from the Toy and Terrier groups. However, many of the dogs were cross breeds, and so size is very difficult to determine. Although breed group was controlled for in the current analysis, this may not fully account for behavioural differences due to size, which may have biased the results.

The current study did not include any questions probing the nature of the relationship between the owner and their dog. There are several validated scales measuring this, including the Monash Dog Owner Relationship Scale (MDORS) (Dwyer et al., 2105) and the Dog Attachment Questionnaire

(DAQ) (Archer & Ireland, 2015). These scales may be interesting to include both as predictors of dog behaviour and also as outcomes: several studies suggest that dog behavioural characteristics may relate to the quality of relationship between dogs and their owners (Hoffman et al., 2015).

In order to causally test whether the range of negative behavioural effects of intensive breeding come about through dysregulation of the HPA axis and other neuro-endocrine systems, researchers may wish to compare measures of physiological markers such as circulating levels of cortisol, oxytocin, and heart rate at various points during the development of puppies from various sources. For example, measurements of oxytocin and stress (cortisol) may give an indication of attachment style (Atzil et al., 2011). Separation anxiety and attention seeking behaviours in dogs have both been linked to improper attachment patterns (Serpell et al., 2016), which have known links to affect regulation in humans (Mikulincer et al., 2003), and possibly HPA axis dysregulation (Kidd et al., 2013). Furthermore, HPA axis dysregulation through mechanisms such as chronic elevation of plasma corticosteroids and decreased feedback inhibition of corticotropin-releasing hormone during development may be responsible for increasing the incidence of fear and aggression-related behaviours in dogs (Braastad, 1998; Weinstock, 2008). While the various negative behavioural outcomes may share patterns in their developmental triggers, more specific factors may lead to the preferential development of one type of response over the other (e.g. of fear over aggression). Given the difference in results between this study and those of McMillan (2013), it might be interesting to investigate whether there are systematic differences between the US and UK commercial breeding environments which could account for the relative higher effect on aggression in American CBE dogs compared to those from puppy farms in the UK, and whether this is reflected in canine physiological development.

Conclusions

Puppy farming has a negative effect on 11 of 14 subscales of the mini C-BARQ, and on both medical health scales measuring infectious and chronic illnesses. A variety of new measures have been developed that might help measure the effects of poor early life experience in dogs. Although walking and training were both found to have an effect on reducing mini C-BARQ score, more research is necessary to determine the nature of this relation. Overall, these results confirm the impact of puppy farming on canine behaviour and health and underline the need for tighter legislation to curb this practice.

Acknowledgements

The authors would like to thank all the organisations which forwarded and publicised the questionnaire and allowed a wider pool of participants to be reached. This research did not receive any specific grants from funding agencies in the public, commercial, or not-for-profit sectors.

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Tables and Figures:

Table 1: Reliability analysis for new scales and subscales

Scale Name	Number of items	Cronbach's Alpha	Scale retained?
Owner Care	5	0.35	*No*
Training	2	.	*No*
Walking	2	.	*Yes*
Puppy Experience	10	0.78	*Yes*
Seller Experience	7	0.75	*Yes*
Medical Symptoms	8	0.71	*Yes*
Infectious Illnesses	4	0.60	*Yes*
Congenital Illnesses	4	0.63	*Yes*

Table 2: Subscale reliability of the C-BARQ(s)

Subscale	No. items	Transform	Current α	Duffy (2014) α
Stranger-Directed Aggression	3	Binary	0.797	0.775
Owner-Directed Aggression	3	Binary	0.839	0.886
Dog Rivalry	2	Binary	0.857	0.829
Dog-Directed Aggression	2	Binary	0.820	0.796
Stranger-Directed Fear	2	Binary	0.906	0.799
Non-Social Fear	3	Binary	0.681	0.625
Dog-Directed Fear	2	Binary	0.847	0.804
Touch Sensitivity	2	Binary	0.708	0.730
Separation Related Behaviour	3	Binary	0.750	0.767
Excitability	2	None	0.770	0.819
Attachment/Attention Seeking	2	None	0.758	0.804
Training Difficulty	3	None	0.629	0.504
Chasing	2	None	0.807	0.845
Energy Levels	2	None	0.788	0.841

Table 3: Factor loadings following Principle axis factoring on the 14 mini C-BARQ subscales.

Subscale	**1 Fear**	**2 Attachment issues**	**3 Familiar aggression**	**4 Impulsivity**	**5 Unfamiliar aggression**	**Communalities**
Excitability		**0.377**				0.196
Stranger Aggression	0.276				**-0.408**	0.436
Owner Aggression			**0.694**			0.454
Dog Aggression					**-0.819**	0.789
Dog Rivalry			**0.618**		-0.207	0.484
Stranger Fear	**0.716**					0.513
Nonsocial Fear	**0.708**					0.515
Dog Fear	**0.547**				-0.256	0.433
Touch Sensitivity	**0.331**		0.213			0.231
Separation Anxiety		**0.363**				0.270
Attention Seeking		**0.612**				0.369
Training Difficulty				**0.457**		0.234
Chasing				**0.511**		0.284
Energy		0.256		**0.377**		0.247
Cronbach's α	**0.816**	**0.709**	**0.785**	**0.68**	**0.82**	

Loading scores below 0.2 are omitted for clarity, and loadings above 0.3 are bolded.

Table 4: Factor loadings following second order Principle Axis Factoring on the five extracted first order factors.

	General Factor	**Communalities**
Fear	0.653	0.426
Attachment Issues	0.526	0.277
Familiar Aggression	0.639	0.409
Impulsivity	0.666	0.443
Unfamiliar aggression	-0.464	0.215

Figure 1: Diagram illustrating the extracted hierarchical factor structure from the 14 C-BARQ subscales using Principle Axis factoring. Five latent factors are extracted at the first level, and one general latent factor is extracted at the second level. Arrows show the direction of the effects and are labelled with factor loadings score, with error terms denoted as "u".

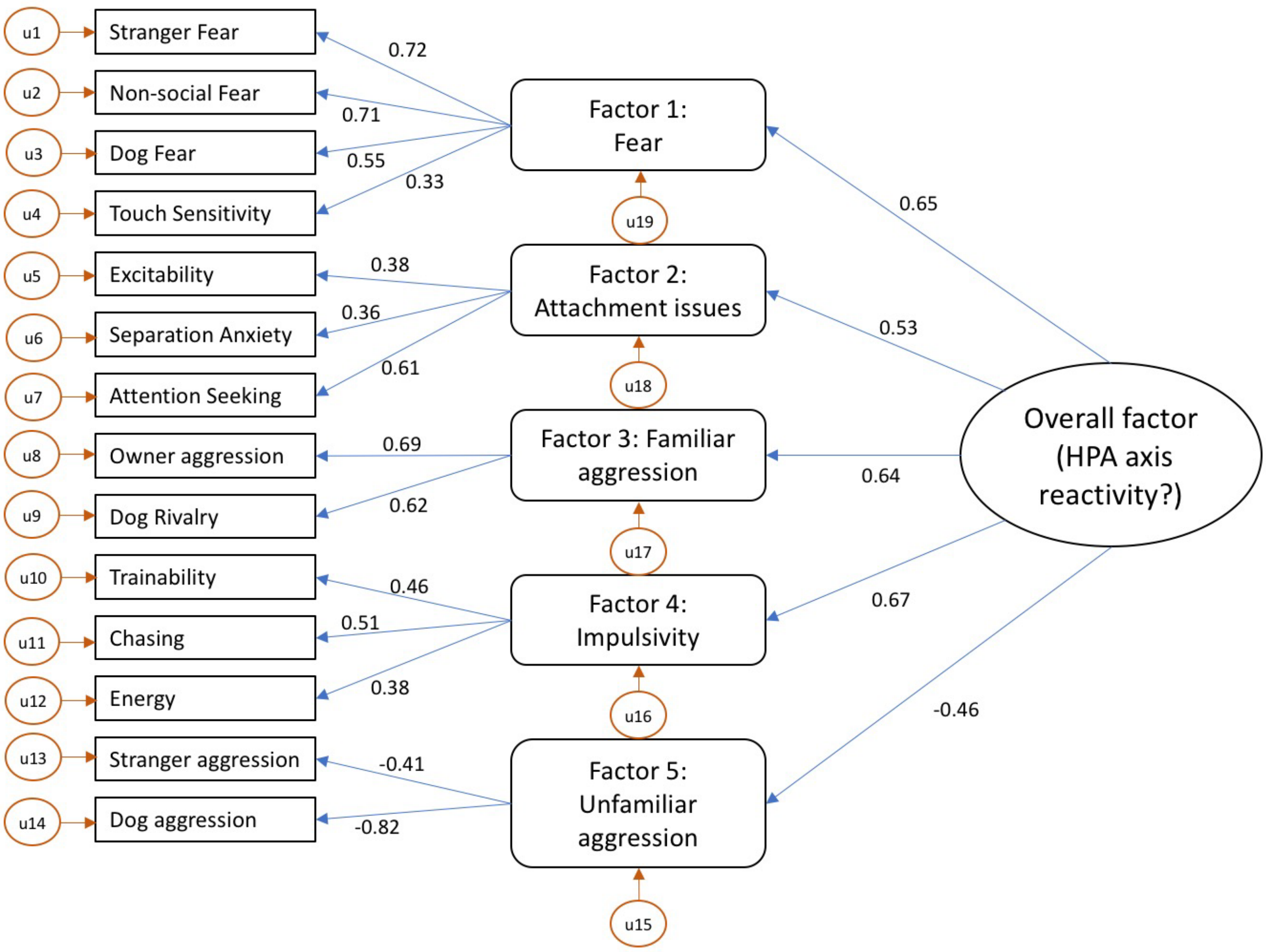


Table 5: Source of different breed groups

Breed Group	**No. from 'other source'**	**No. from 'puppy farm' (%)**	**% of puppy farm total (n=123)**
Gundog	454	12 (2.6%)	9.5%
Pastoral	248	12 (4.6%)	9.5%
Working	87	5 (5.4%)	4.1%
Hound	59	5 (7.8%)	4.1%
Terrier	222	19 (7.8%)	15.4%
Toy	116	23 (16.5%)	18.7%
Utility	114	8 (6.6%)	6.5%
Cross-breed	389	37 (8.7%)	30.1%

**The 'wolfdog' breed group was excluded as it only had 15 dogs, and is not officially recognised by the UK Kennel Club*

Table 6: Summary of binary logistic regressions comparing the behavioural scores of dogs from puppy farm vs. dogs from other sources

Subscale	Variables controlled[2]	Odds Ratio	95% C.I.	p- value[3]	
Stranger-Directed Aggression	1, 2, 3, 4	1.87	1.20-2.90	0.005	*
Owner-Directed Aggression	2, 4, 5	1.92	1.24-2.98	0.004	*
Dog-Directed Aggression	1, 3, 4, 5	1.61	1.04-2.50	0.032	*
Dog Rivalry	1, 2, 4	1.59	1.00-2.51	0.048	
Stranger-Directed Fear	2, 4, 5	2.16	1.48-3.20	<0.001	*
Non-Social Fear	1, 2, 3, 4	2.49	1.37-4.51	0.003	*
Dog-Directed Fear	2, 3, 4, 5	1.63	1.02-2.60	0.039	*
Touch Sensitivity	2, 3, 4	1.80	1.19-2.57	0.004	*
Separation Related Behaviour	1, 4	1.87	1.21-2.91	0.005	*

[1]Non-puppy farm dogs were the reference category: Odds Ratio corresponds to the odds of shifting from a score of 0 to a score above 0 on the C-BARQ for that subscale if the dog came from a puppy farm.
[2]All controls were included in original regression, and non-significant variables (p<0.05 level) were removed for final model estimations; 1=age, 2=neutered, 3=other dogs, 4=breed, 5=sex.
[3] *= significant with Benjamini-Hochberg correction

Table 7: Summary of linear regressions investigating the behavioural scores of dogs from puppy farms vs. dogs from other sources

Subscale	Variables controlled[1]	Coef. B	95% C.I.	p- value	
Excitability	1, 4	0.11	0.02-0.20	0.017	*
Attachment/Attention Seeking	1, 4	0.19	0.11-0.28	<0.001	*
Training Difficulty	1, 2, 4	0.12	0.06-0.18	<0.001	*
Chasing	1, 2, 3, 4	0.07	-0.05-0.11	0.241	
Energy Levels	1, 4, 5	0.04	-0.06-0.12	0.445	

[1]See Table 4 for key

Table 8: Summary of statistics for hierarchical model predicting overall C-BARQ(s) score

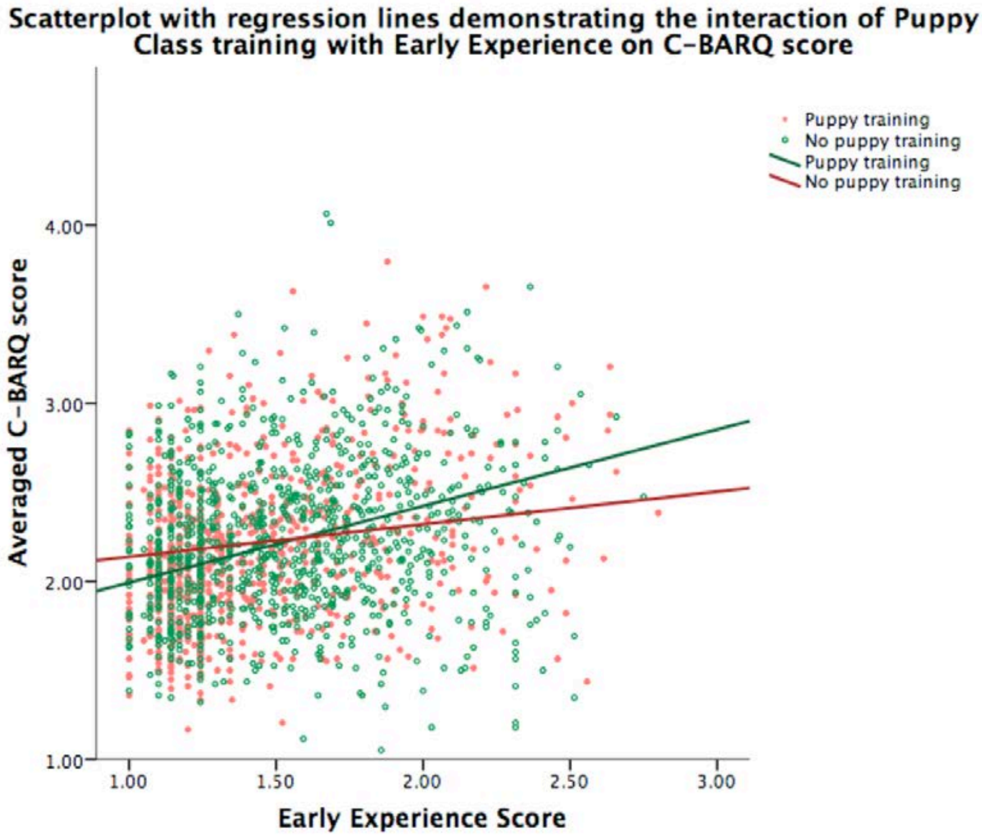
	R^2	F (df)	ΔR^2	ΔF (df)	Sig. F change
Block 1	0.042	15.406 (5, 1749)	0.042	15.406 (5, 1749)	<0.001
Block 1+2	0.104	22.502 (9, 1745)	0.062	30.090 (4, 1745)	<0.001
Block 1+2+3	0.119	19.625 (12, 1742)	0.015	9.954 (3, 1742)	<0.001

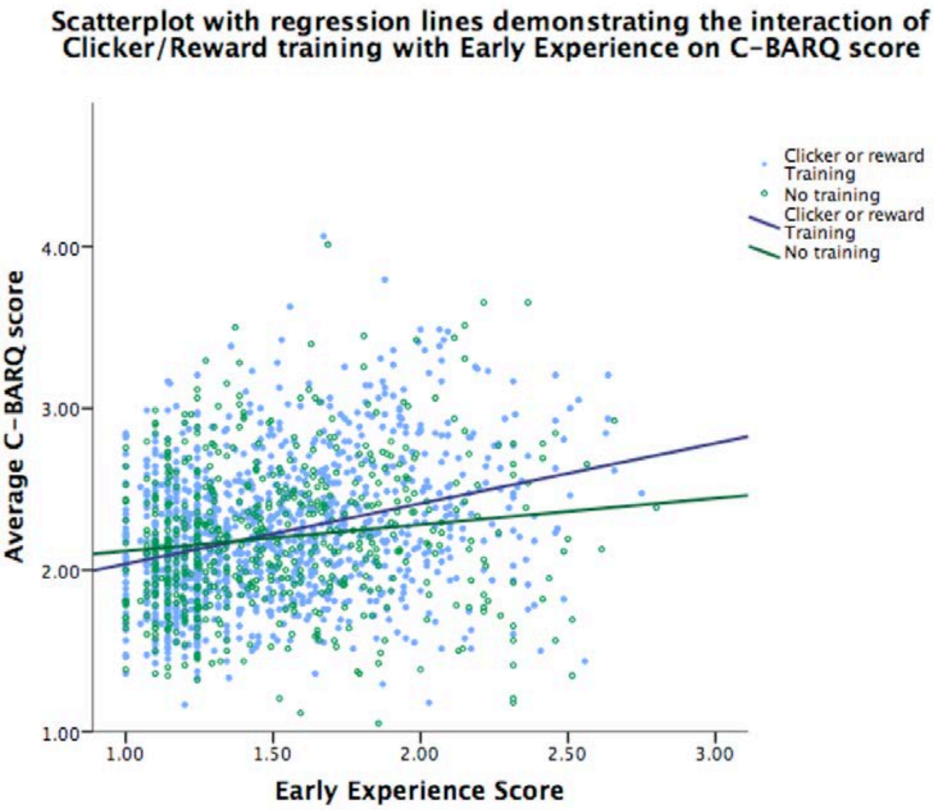
Coefficients values (by block) in final Model

	B	95% C.I.	p-value	
Age	-0.022	-0.042 to -0.003	0.023	
Sex	-0.024	-0.062 to 0.014	0.212	
Neuter	-0.059	-0.103 to -0.015	0.009	*
Breed	0.013	0.006 to 0.020	<0.001	*
Other dogs	-0.095	-0.139 to -0.051	<0.001	*
Early Experience	0.265	0.210 to 0.319	<0.001	*
Clicker/reward	-0.009	-0.030 to 0.012	0.410	
Puppy classes	0.011	-0.009 to 0.031	0.284	
Walking scale	0.060	0.038 to 0.319	<0.001	*
'Early Experience' x Clicker/reward	-0.096	-0.144 to -0.033	0.002	*
'Early Experience' x Puppy classes	-0.088	-0.150 to -0.041	0.001	*
'Early Experience' x Walking scale	-0.043	-0.101 to 0.015	0.146	

*= significant under Benjamini Hochberg Correction

Interpreting coefficients: *lower* C-BARQ scores demonstrate more desirable behaviours. Lower scores for 'Early Experience' indicates better early life experience, lower walking scores correspond to *more* walking, and lower training score indicate *more* training.


Scatterplot with regression lines demonstrating the interaction of Puppy Class training with Early Experience on C-BARQ score
Puppy training
No puppy training
Puppy training
No puppy training
Averaged C-BARQ score
4.00
3.00
2.00
1.00
1.00
1.50
2.00
2.50
3.00
Early Experience Score


Scatterplot with regression lines demonstrating the interaction of Clicker/Reward training with Early Experience on C-BARQ score
Clicker or reward Training
No training
Clicker or reward Training
No training
Average C-BARQ score
4.00
3.00
2.00
1.00
1.00
1.50
2.00
2.50
3.00
Early Experience Score

Figu
of tr

Table 9- Summary of statistics for main effects and interaction terms for each of the extracted subscales.

	Parameter Estimates	Early experience	Clicker/reward training	Puppy classes	Walking scale	EE * Clicker/reward	EE * Puppy classes	EE* Walking scale
Factor 1- Fear[1]	B	0.225	-0.007	-0.003	0.037	-0.029	-0.077	-0.018
	95% C.I.	0.181	-0.024	-0.019	0.019	-0.074	-0.121	-0.064
		0.269	0.009	0.013	0.054	0.016	-0.033	0.029
	p-value	**<0.001***	0.380	0.72	**<0.001***	0.200	**<0.001***	0.460
Factor 2- Attachment Difficulties[2]	B	0.266	-0.007	0.061	0.070	-0.092	-0.05	-0.01
	95% C.I.	0.185	-0.038	0.032	0.038	-0.175	-0.131	-0.096
		0.348	0.024	0.091	0.102	-0.010	0.031	0.076
	p-value	**<0.001***	0.639	**<0.001***	**<0.001***	**0.029**	0.225	0.820
Factor 3- Familiar Aggression[3]	B	0.575	-0.066	0.015	0.186	0.122	-0.25	0.129
	95% C.I.	0.286	-0.178	-0.091	0.074	-0.171	-0.537	-0.171
		0.864	0.047	0.121	0.298	0.415	0.038	0.430
	p-value	**<0.001***	0.252	0.784	**0.001***	0.413	0.089	0.399
Factor 4- Impulsiveness[2]	B	0.118	-0.01	0.032	-0.007	-0.135	-0.01	-0.1
	95% C.I.	0.031	-0.043	0.001	-0.041	-0.223	-0.097	-0.192
		0.205	0.023	0.063	0.027	-0.046	0.076	-0.008
	p-value	**0.008***	0.542	**0.045**	0.676	**0.003***	0.815	**0.033**
Factor 5- Unfamiliar Aggression[1]	B	0.165	0.006	-0.013	0.061	-0.046	-0.092	-0.003
	95% C.I.	0.116	-0.013	-0.030	0.042	-0.096	-0.141	-0.055
		0.214	0.024	0.005	0.080	0.005	-0.042	0.049
	p-value	**<0.001***	0.541	0.153	**<0.001***	0.074	**<0.001***	0.902

[1]Analysed using a mixed model GLM with Gamma Log link, [2]Analysed using a mixed model GLM with normal distribution, [3] Analyzed using a mixed model Binary Logistic GLM
Values in bold are below p=0.05, starred values are significant under Benjamini Hochberg correction

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